

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

**Shipyard Organization
and Management Development**

US. DEPARTMENT OF TRANSPORTATION
Maritime Administration
in cooperation with
Todd Pacific Shipyards Corporation

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FOREWORD

Research into various other aspects of Ishiwajima-Harima Heavy Industries' (IHI's) shipbuilding system led to suspicion that Japanese and American shipbuilders differed greatly in their development and employment of college-educated middle management. The research indicated that Japanese shipbuilders cultivate and exploit middle management to a far greater degree. Thus, additional research was begun under the title, "Role and Development of Middle Management."

Later, discovery was made that IHI's management development approach conformed with basic principles of organization and management as taught in U.S. universities. Thus, the project was redirected to include the influence of traditional functional organization versus a product organization such as IHI's. This report concludes that an effective management development program is impossible with a traditional functional organization.

Further, the research disclosed that:

IHI's impressive management development program was possible because of a form of product organization applied to shipbuilding, and

far from being the result of Japanese culture, the marriage of product organization and management development is regarded as vital by various outstanding firms in the U.S. and is well documented by American academia.

Japanese shipbuilding managers seem to have read U.S. textbooks. Thus, the appropriate question is not, "What are the Japanese doing?" Instead, it is, "What are U.S. shipbuilders not doing?"

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EX SCIENTIA EFFICIENS

“Only America can surpass Japan in shipbuilding. But, we do not worry because America has a human problem: not enough college educated people in middle management.”

Hisashi Shinto
October 1979

“Shishi” is the name the Japanese have given to those young samurai, in their twenties and early thirties, who risked their lives to bring down the outdated Tokugawa Shogunate and establish a modern state in Japan. Many of them were assassinated or executed. But Shishi means “determined warrior”. In their maturity who as youths had striven mightily, became the leaders in the new Meiji Government which modernized Japan.

*Today, the US. shipbuilding industry is being struck by a worldwide shipbuilding recession. Not only America is affected. Shipbuilding is contracting everywhere. But the same recession, by also shaking out traditionalism, ignorance, complacency and servile reliance on governments, is creating need for young college-educated people who have knowledge of the most **effective** shipbuilding principles. Most top managers now understand that survival is dependent on command of very scientific methods and the methods are dependent upon more college-educated people in middle management.*

Thus, this publication is dedicated to those Shishi who are bearing the challenges of the current shipbuilding revolution.

1.0 Introduction

When interviewed by the Washington Post in April 1983, Dr. H. Shinto, perhaps the foremost shipbuilding authority in Japan, noted that when he first visited America in the early fifties he observed that college-educated engineers pervaded the workshops. "The engineers knew the production program, and they knew how to use machine tools. Because they knew the production process in detail, they were able to get greater productivity and high quality.¹¹ He added that during his visit to the U.S. in 1980, he "... didn't find the same kind of intelligence in the workshop." [1]

This paper began as a report on the management development program of Ishikawajima-Harima Heavy Industries (IHI) of Japan. Dr. Shinto's emphasis on the role of middle management in the shipyard was the impetus. However, research soon disclosed that another, related but much wider topic needed to be addressed: shipyard organizational structure and design.

Between 1950 and 1970, an extraordinary change occurred among the U.S. Fortune 500 companies. In 1950

[1] Dr. H. Shinto, former President of Ishikawajima-Harima Heavy Industries of Japan, is now President of Japan Telegraph and Telephone Corporation.

just 20.3% of them were product organizations while as many as 62.2% were in functional organizations. As shown in Figure 1, within two decades, 75.9% of the Fortune 500 had adopted product organizations while the number retaining functional organizations plunged to 11.2%. [2]

In the middle of the same time frame, i.e., the early sixties, shipbuilders in Japan abandoned functional and adopted product organizations based on a Product Work Breakdown Structure (PWBS). In contrast, no such revolution occurred in the U.S. shipbuilding industry. [3]

2.0 Functional and Product Organizations

The two basic forms of organization are functional and product. All other forms, such as matrix, are hybrids.

A functional structure groups resources into common activities. Engineers are organized per function and production people are organized per function. A product structure is based on a PWBS and Group Technology which permits diversification, i.e., a multi-

[2] Richard P. Rumelt, "Strategy, Structure and Economic Performance", Division of Research, Harvard Business School, Boston, 1974, p.65.

[3] Y. Okayama and L.D. Chirillo, "Product Work Breakdown Structure - Revised December 1982", for the National Shipbuilding Research Program (NSRP).

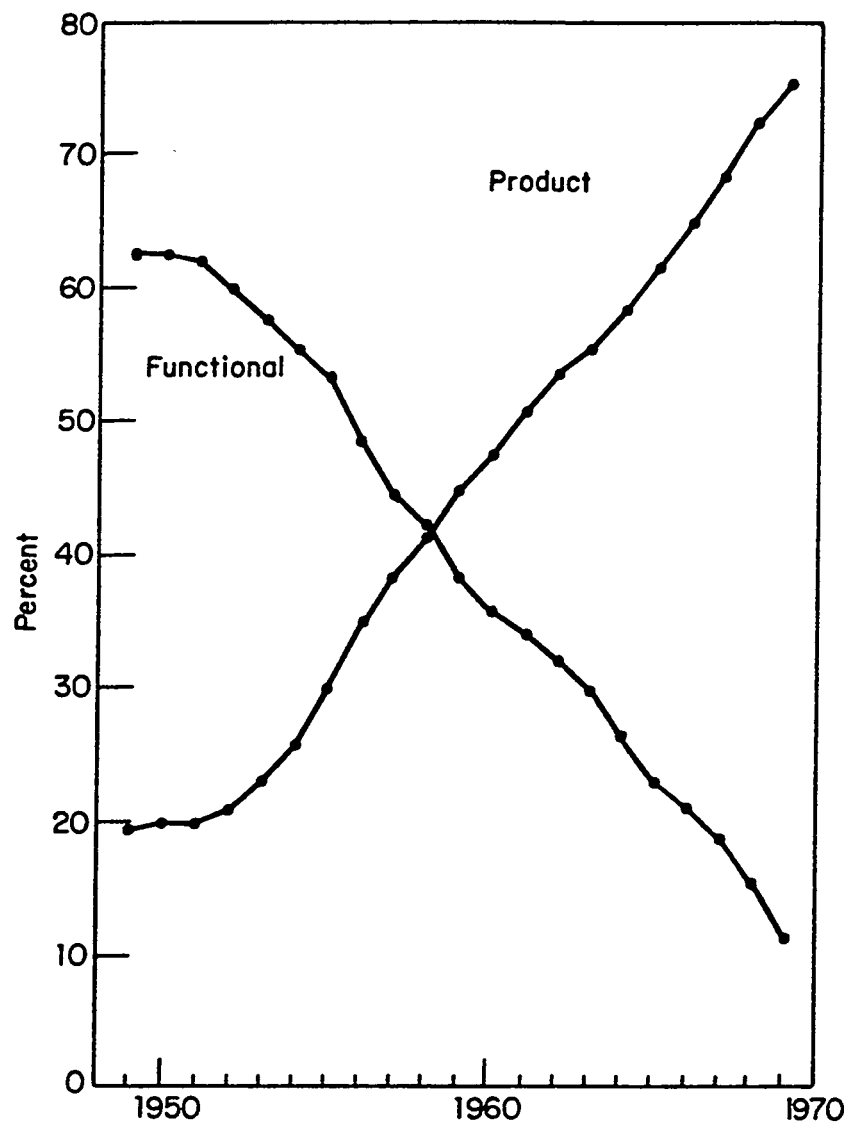


FIGURE 1: Transformation of Fortune 500 companies from functional to product organizations between 1949 and 1969. From Richard P. Rumelt, "Strategy, Structure and Economic Performance," Division of Research, Harvard Business School, Boston, 1974, p. 66.

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product line. Design and production are organized in the same way, both aimed at the same products, in the case of shipbuilding, interim products.

Functional organization, as an organization type, is best when a firm makes only one or a few products and where technology does not change. Traditionalists in shipbuilding look simplistically at the entire ship as the end product of a shipyard. Modern shipyard managers, however, "...break down an envisioned end product into interim products, i.e., parts and tiers of subassemblies, which are contrived to facilitate creation of larger assemblies and which are assigned for manufacture to the most specialized and cost effective producers, in-house or else where. Such advanced shipbuilding is said to be product (interim product) oriented and is primarily an assembly process." [4]

The ship as an end product becomes incidental as the end product could be other than a ship, i.e., bridge, chemical plant, power plant, etc. Whatever the end product, modern shipyard managers are designers and producers of many interim products. This focus on interim product makes it possible for large firms, like IHI, to better cope with technological change and multiple markets.

[4] "Product Oriented Material Management - June 1985", NSRP.

3.0 Two Levels of General Management

The product structure implies the existence of at least two levels of general management and an increase in the number of general management roles over that of a functional structure. " [5]

In a study of the development of 70 large American corporations, the impact of the change from functional to product organization was described as creating two levels of general management which, 11. ...removed the executives responsible for the destiny of the entire enterprise from the more routine operational activities and so gave them time, information and even psychological commitment for long-term planning and appraisal. Conversely, it placed the responsibility and necessary authority for the operational administration in the hands of the general managers of the multifunction divisions." [6]

Having more than one enterprise, the two tier management concept is exploited to the utmost by IHI. In each shipyard, although the title "general manager" is used, the incumbent has less responsibilities than a typical American general manager and more responsibilities than are generally associated with the title "operations manager". For the purpose of maintaining a

[5] Richard P. Rumelt, Ibid, p.33.

[6] Alfred D. Chandler, Jr., "Strategy and Structure", Doubleday and Company, Garden City, N.Y., 1962, p.382.

distinction, the title "principal operating manager" (POM) is used hereinafter.

POM responsibilities include the following functions of the management cycle that applies for all industrial processes:

- o planning (design and material definition are aspects of planning),
- o scheduling, and
- o executing (includes material procurement and marshalling as well as production).

Regarding design, the POM is responsible for all aspects except basic design when a central basic design office exists.

Further, a POM is not distracted by business affairs such as accounts payable or receivable. Above all, a POM is concerned only with matters that are internal to the shipyard which directly affect production and is not involved in external matters, e.g., sales, business acquisitions, and lobbying. Another way to characterize the role of POM vis-a-vis top management is that POM is concerned with current return on investment while growth through investment in new products and businesses is the role of top management.

4.0 Design Production Integration

Integration is the quality of collaboration between departments. [7]

An almost constant complaint by traditionalists is that design and production fail to collaborate. Everyone realizes that this lack of integration is extremely costly and adversely impacts on morale. While admitting the problem, traditionalists have long failed at a solution. This is because the fault does not lie, as traditionalists imagine, with individuals in either design or production.

"When people act at cross purposes or under pressure to achieve departmental goals at the expense of organizational goals the (organizational) structure is often at fault." This is the case if "... breakdowns occur when people at the operational level who see changing contingencies cannot feed information into the planning and objective setting at higher levels.¹¹ A good example is the need to get production people involved in contract design. [8] [9]

[7] J.W. Lorsch, "Introduction to the Structural Design of Organizations", in "Organization Structure and Design", Irwin and Dorsey, Homewood, Illinois, 1970, p.5.

[8] Richard L. Daft, "Organization, Theory and Design", West Publishing Company, Saint Paul, Minnesota, 1983, p.250.

[9] "Pre-Contract Negotiation of Technical Matters - December 1984", NSRP.

Lack of communication between departments is a fundamental weakness of functional organization structure. "The similarity within each department causes employees to adopt similar values, goals and orientations. Similarity encourages collaboration, efficiency, and quality within the function but makes coordination and cooperation with other departments more difficult. The functional structure places the emphasis on expertise within functions rather than on horizontal coordination." For a small company, that does not deal in anything complex, functional organization will serve. By virtue of its size, a small company is able to maintain needed levels of communication despite a functional organization. [10]

But in a large organization dealing with complex technology, product organizational structure groups both design and production by product, in the case of shipbuilding by interim product. People, information and work are organized in the same way. Thus, communication and identification of design and production . employees centers around everything it takes to produce their assigned interim product. Collaboration across functions is "excellent". [11]

[10] Richard L. Daft, Ibid, p.226.

[11] Ibid, p.231.

5.0 Product Organization and Management Development

With the breakthrough into product organization, came many benefits in addition to design production integration. Among these, Japanese shipbuilders found that cost control was enhanced. The production of each class of interim products was handled like a separate business. Production control was enhanced as the more logical division of work allowed statistical control methods to be applied to work processes with greater effectiveness. Together with the above, Japanese shipbuilders were able to exploit their product organizations to promote in a systematic and conscious way management development. [12]

In IHI, product organization is the basis for a successful management development program. Because of the differences in how functional and product organizations are constructed, management development and personal advancement are highly affected. Product organizations act as a ". ..built in 'school of management', training middle level general managers in the problems and opportunities associated with economic responsibility". [13]

[12] Ibid.

[13] Bruce R. Scott, "Stages of Corporate Development", unpublished paper, Harvard Business School, 1970, p.14.

In traditional organizations people come up from functional shops or departments. "Promotion up the hierarchy is normally on the basis of experience and expertise within the function". Such managers understand in exhausting detail the vagaries of the shop or department from which they came, but they do not understand either other shops or the relations between shops. Theirs is a parochial, not systemic view of manufacturing. [14]

In IHI, as in the U.S. military, young, college educated people are moved from post to post (job rotation) . In large corporations this approach is made practical by a product organization. A product organization insures that promotion into higher management is¹¹ . ..on the basis of management and integration skills rather than on the basis of functional expertise. Managers must be able to achieve coordination across functions rather than to be an expert in any single

[14] Richard L. Daft, Ibid, p.227.

[15] Ibid, p.231.

an institution that cannot produce its own managers will die The ability of an institution to produce managers is more important than its ability to produce efficiently and cheaply."

Peter F. Drucker

6.0 Aspects of a Management Development System

There is nothing inherently "Japanese" in the IHI management development process. Many of the same techniques are used by other firms, e.g., IBM, Exxon and Citibank. With its product organization and management development program, IHI's corporate culture much more resembles IBM or Exxon than any U.S. shipbuilding firm.

Some common threads that run through successful management development programs including those at IHI, IBM, Exxon and Citibank are:

- o "They are built deep into the system, involving all levels of management and affecting the way the organization works. 'We don't hire management trainees' says Edward F. Krieg, IBM Director of Management Development. 'We go after (technically) competent people and provide a crucible where they can evolve into managers' .
- o "Management development is part of every managers job. Each executive is responsible for grooming his subordinates. His salary and promotions are based partly on their success.
- o "Top management support and a long-term commitment to the program are unwavering. Otherwise, movement of executives in and out of learning jobs (job rotation) comes to an end." [16]

[16] Business Week, "How Companies Raise a New Crop of Managers", 10 March 1975, p.44.

"We used a group of junior engineers. ..shifting
them frequently from one department to another --
most became top-notch supervision . . ."

Elmer L. Harm

7.0 IHI Management Development

IHI's mission is to supply products and services of high quality for reasonable reward in compliance with the demands of society. At the same time, the company is dependent upon human creativity. Thus, development of the individual is a fundamental function of management on the same level with production. Development of the individual and development of the manufacturing system go hand in hand. Most importantly, individual development is not subjected to the short-term vagaries of management. Career planning is done on a one-year and three-year basis for each new graduate. Each year these plans are updated. The management development plan is part of IHI's overall management plan, having much to do with the future of the enterprise. Long-term continuity is essential. [17]

The purpose of the management development program is to forge by instruction and discipline, a person who embodies the goals of IHI. All during the development period, IHI will entrust the person with greater responsibility. Eventually, IHI may entrust the person with company leadership overall.

[17] IHI's management development practices were submitted by IHI Marine Technology, Inc. in response to the NSRP project "Role and Development of Middle Managers".

Each year, all IHI department managers project their personnel needs for the next ten years. Then, they instruct the Personnel Department on the number of college graduates they require for the coming year. The Personnel Department hires all new college graduates for all departments simultaneously. As a result, all graduates joining the company in a given year form a class. In the early years of their service with the company, seniority, based on their class year, serves as the basis for advancement. Later, ability will separate out the few who will continue to climb the corporate pyramid. The necessary attrition is effected by moving surplus experienced people to other organizations in which IHI has interests, e.g., domestic subsidiaries, overseas project offices and consultancies. Because these people are managerial generalists as well as technical experts they can be of service in many different industries. In Exxon as in IHI, "The life-blood of our management development system is the rate at which we can move talent through the management ranks, always providing a greater challenge." says Frank Gaines, Jr., Executive Development Coordinator at Exxon. [18]

[18] Business Week, Ibid.

In 1983, IHI's shipbuilding division hired 27 graduates, five of whom held post-graduate degrees. A slightly higher number was hired in 1984. These new employees were assigned to IHI's head office and four shipyards. All together, college graduates typically account for 3% of total shipyard personnel, not counting those assigned to basic design. This percentage includes a small number of high-school graduates who demonstrated analytical ability and who rose through company educational opportunities. [19]

Two important aspects of IHI's management development program are that it is organized and given a high priority by top management. Development is carried out through:

- o departmental on-the-job training,
- o courses for technical specialists,
- o courses on financial affairs, computers, management, documentation, etc., and
- o courses on written and spoken communication.

The most critical of the above is on-the-job training. Here newcomers are assigned to shops or departments where managers are drilled in manage-

[19] As a matter of interest to students of leadership and organizations, per the U.S. Army's Fort Lewis Public Information Office, a combat infantry brigade of 3,000 soldiers contains a complement of 90 officers, i.e., 3%. In IHI's shipyards, the college-educated leadership is also 3%.

ment development techniques. In implementing their development roles, managers must:

- o always be conscious of their development responsibilities (to help subordinates progress is the most crucial jobs of line managers),
- o train people to master fundamentals from the start (this includes drill in the logic and principles concerning their work as a stable foundation for future advancement),
- o not put every person in the same mold (a proper development plan is according to a person's ability, character and strong points),
- o demand from their people responsibility and competence (this is the greatest catalyst for individual growth),
- o must assign jobs which challenge current knowledge and experience, and
- o note results after assignments are completed.

Job rotation is carried on for a full 12 years after a graduate joins IHI. For the first two years, every graduate is assigned to some aspect of design. At the end of two years they are transferred to production. Thus, the company assures itself that its prospective management personnel experience the dynamics between design and production and the need for constant communications between the two. This is over and above the fact that IHI's product organization affords much

better design production integration than the functional organizations used elsewhere by shipbuilders.

Each person's career plan is updated annually through interviews with section and department managers. In discussing available career options, the desires and talents of the individual are taken into account. A typical managerial career might feature the following assignments:

- o engineer - any outfit design group,
- o field engineer - mold loft,
- o field engineer - erection shop,
- o field engineer - machinery outfitting shop,
- o field engineer - painting shop,
- o shop manager or senior production engineer in hull construction or outfitting departments,
- o manager of the hull construction or outfitting department,
- o manager of the production control department,
- o assistant general manager, and
- o general manager.

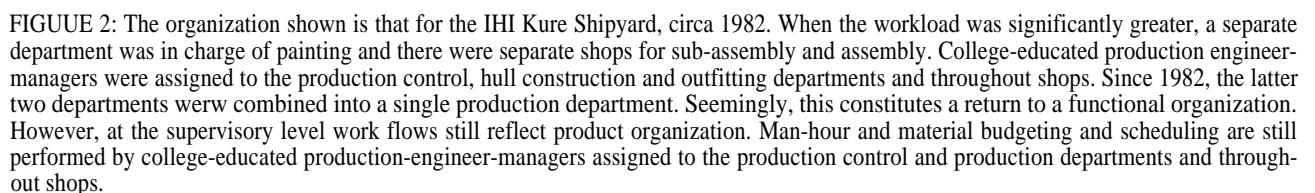
Typical responsibilities implemented by college-educated people assigned early in their managerial careers to shops are listed in Appendices A and B. Basically, in behalf of shop managers, they are responsible for budgeting man-hours and materials to, and scheduling the operation of, work flows within shops.

Fully developed engineer-managers are experienced in the entire industrial process. They are well educated, well trained people who are aware of their ability and obligation to constantly improve the manufacturing system. They are well prepared to step into higher management positions. They have a strong technical base, yet they are managerial generalists as well. They are, indeed, an elite group.

8.0 Summary

IHI's shipyard organization, Figure 2, is a form of product organization applied to shipbuilding. People, information and work are all organized so as to exactly match the PWBS employed. As shown in Figure 3, the strength is in the exact matching of the organization of shop work to how costs are collected. PWBS, therefore, is the framework upon which shipbuilders can erect a product organization.

Also, the importance of highly educated, highly trained analytical thinkers to a modern, advanced manufacturing system cannot be denied. Scientific shipbuilding techniques demand college-educated engineer-managers. Functional organizations, traditional in the U.S. shipbuilding industry, fail to produce managerial generalists with a strong technical base. Product organization is the foundation upon which a corps of engineer-managers can be constructed. Current challenges, particularly for building warships, requires managers of shipyards to become more organized, purposeful and sophisticated in their use of college-educated middle management.



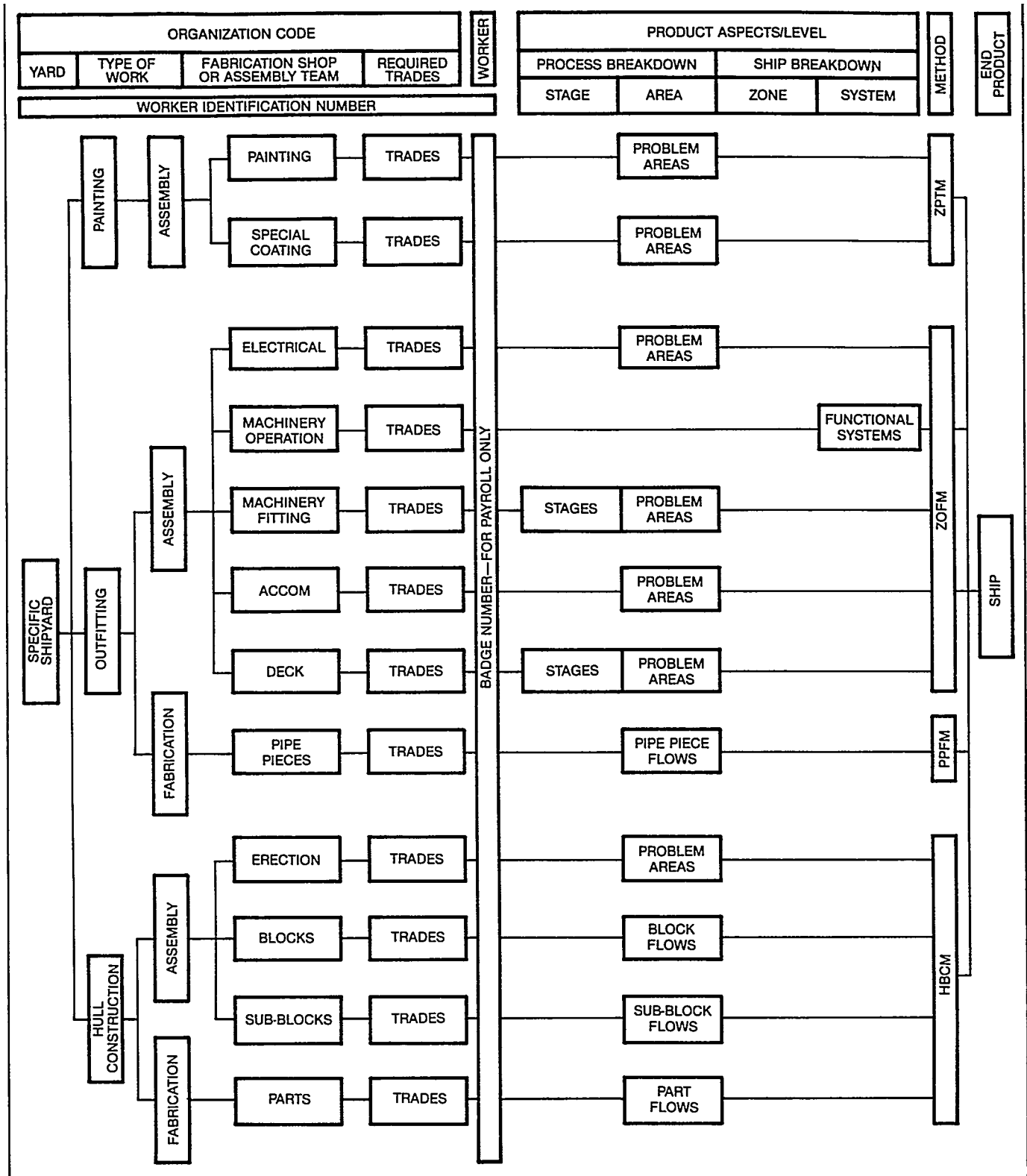


FIGURE 3: From the left looking to the right, is the IHI shipyard organization, circa 1975, when shipbuilding peaked in Japan. From the right looking left, is the product work breakdown structure (PWBS) employed. In the decade following, commensurate with the shipbuilding recession and a 45% work force reduction, painting was changed from a two-shop department to a single shop; sub-block assembly and block assembly were assigned to one shop manager and the separate departments were replaced by a single production department. Such changes impacted on department and shop levels only. For budgeting and costing purposes, work flows by interim-product categories at supervisory levels within shops remained separated so as to continue to match the PWBS.

APPENDIX A

Typical Responsibilities for College-Educated Staff People Assigned to an Outfitting Fabrication Shop (e.g., for manufacturing pipe pieces)

Special Activities

- a. For each building contract, budget man-hours and materials allocated to the shop to the various flow lanes based on records of efficiency achieved and also based on planned improvements in work methods, e.g., automatic welding, and better jigs and tools.
- b. Maintain a long-term (1 year) shop loading plan and revise it in response to every change in the shipyard's master schedule.
- c. Manage the use of subcontractors and the use of overtime to offset workload fluctuations.
- d. Negotiate with subcontractors and settle on volumes of work and unit prices that are to apply for a one-year period.
- e. Estimate work associated with drawings, material lists and other information provided by designers.
- f. Develop intermediate-term (3 months) schedules to meet pallet required dates using feedback, i.e., man-hours per unit **weight**, per pipe piece, per electric-cable lengths, etc.
- g. Maintain man-hour control graphs per ship by the parameters used for feedback.
- h. Maintain the data bank for computer processing of information, e.g., lot number and serial number for control during fabrication vs. ship number, part number and pallet number needed for control during assembly on-unit, on-block and on-board.
- i. Plan facilities improvements.
- j. Implement special projects, e.g., how to make the shop more vivid.

Routine Activities

- a. Preside over weekly meetings attended by the shop manager, flow lane foremen and their assistants and other staff assistants to:
 - o ascertain the number of components completed per week relative to planned output per flow lane,
 - o establish the amounts of work to be accomplished next week, including overtime work and work to be subcontracted, and
 - o establish a manning plan per flow lane for next week's work.
- b. Once each month, prepare the shop manager's report to the department manager presenting the actual trend of production (difference between what was planned and scheduled and final results) and presenting recommendations for improvement.
- c. Maintain the accuracy control system.
- d. Attend safety control meetings which are held twice per month.

APPENDIX B

Typical Responsibilities for College-Educated Staff People Assigned to an Outfitting Assembly Shop (e.g., deck, accommodation, machinery and electrical)

Special Activities

- a. Participate in the study of each preliminary design, before contract design starts, and contribute to a basic build strategy.
- b. Participate in meetings for hull block definition.
- c. Prepare the strategy for zone outfitting by designating zones and stages for outfitting on unit, on block, on grand block and on board and when necessary advising designers of changes in arrangements that would improve productivity without inhibiting owner requirements.
- d. Designate special material required dates such as for a main engine and check for such material availability.
- e. Prepare 3-months and 1-month schedules using the design outputs per pallet and man-hour rates associated with fitting specific materials.
- f. Continue to contribute to further definition of a build strategy as subsequent design phases evolve and eventually inputting information needed to facilitate work, e.g., check points, reference lines, means for air testing welds, so that the output of detail design is, literally, work instructions.
- g. Document the outfitting strategy and establish targets taking into account new ideas for reducing costs.
- h. Prepare the zone-outfitting schedule insuring that it is compatible with the design schedule for preparation of work instructions corresponding to pallets (MLF).
- i. Prepare a staging plan.
- j. Specify access and routes from a safety point of view.
- k. For each building contract, budget man-hours and materials allocated to the shop to the various flow lanes based on records of efficiency achieved and also based on planned improvements in work methods, e.g., automatic welding, and better jigs and tools.
- l. Plan relocations of on-board cranes to anticipate erection progress.
- m. Prepare plans such as for main engine installation, propulsion system alignment, flushing completed pipe systems, etc..

- n. Plan facilities improvements.
- o. Implement special projects assigned by the shop manager.
- p. Maintain an account of shop expenses.
- q. Maintain control charts and analyze results by stage for fitting on block, on grand block and on board.
- r. Document work practices.

Routine Activities

- a. Attend the brief meeting of electric shop foremen each morning.
- b. Preside over the weekly (Tuesday) meeting for finalizing next week's work load specifically by:
 - o checking monthly schedules proposed by foremen and weekly schedules proposed by assistant foremen,
 - o conveying policy conceived by the shop staff for how work is to proceed.
 - o discussing and adjusting the distribution of workers with the foremen, and
- c. Patrol the construction sites twice per day.
- d. Be in attendance during start-up of major equipments.
- e. Resolve owner's and surveyor's reports of unsatisfactory items and process feedback reports.
- f. Attend the ship manager's (superintendent's) weekly ship construction meeting and participate in coordinating decisions with other shops' staff people, particularly for painting.
- g. Once each month, prepare the shop manager's report to the department manager presenting the actual trend of production (difference between what was planned and scheduled and final results) and presenting recommendations for improvement.
- h. Attend the safety control meetings which are held twice per month.

SHIP DESIGN
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